AIDS TO THE CHEMISTRY AND TESTS OF THE PHARMACOPEIA

JAMES DAVISON

FAHNIE & CO.

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BY

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"Non ignara mali miseris succurrere disco."—*Æneid.*

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PREFACE.

An Aid Book to Pharmaceutical Chemistry not having as yet been issued, I venture to publish these notes in hope that they may fill the want. I trust that they may prove useful to at least two classes of students.—First to those who, having worked up the subject previously from a larger treatise, may wish hurriedly to burnish their armour ere they try conclusions with the examiner. Again, to those who, with Professor Huxley, look upon Materia Medicas as books *de omnibus rebus*, and therefore feel obliged to take at least a part of them in as minimised a form as possible. Sympathising with both classes, I have here endeavoured to put the Chemistry and Tests of the Pharmacopœia in the shortest and most concise manner compatible with rendering them intelligible.

So long as medical students are compelled to study nine or ten subjects in two years and a half, and Materia Medica is made to consist of chemistry, botany, zoology, and therapeutics, so long will aid books be a necessity—so long in some of these,

might I say in all, must we continue to merit the saying of the poet—

"A little learning is a dangerous thing."

To those who condemn small books this is my apology.

These notes being intended for medical and pharmaceutical students, the nomenclature of the Pharmacopœia is used in preference to the more correct terms adopted in ordinary manuals of chemistry.

To the student who wishes to understand chemical equations, let him thoroughly comprehend *Quantivalence,* and learn off the names of the substances and their symbols occurring under this head. This will do more than anything else that I know of to facilitate his acquisition of a knowledge of chemistry.

These notes being mainly taken from Attfield, Wilson, and Roscoe's works on the subject, therefore contain nothing new, except in so far as condensation and arrangement are concerned. The student who wishes to pursue the subject at greater length, will find it in abundance in any of these books mentioned.

45 *Lundy's-terrace, Dublin,*
June, 1880.

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ERRATA.

Page 24, line 10—*for* mercurous *read* mercuric.
„ 24, „ 10—*for* mercuric *read* mercurous.
„ 31, „ 19—*for* $KCHO_3$ *read* $NaHCO_3$.
„ 32, „ 15—*for* $ZnCO_32Zn$ *read* $ZnCO_32ZnH_2O_2$.
„ 32, „ 24—*for* $Zn2C_2H_3O_22HO_2$.
read $Zn2C_2H_3O_22H_2O$.
„ 32, „ 27—*for* $3ZnC_2H_3O_2$ *read* $3Zn2C_2H_3O_2$.

AIDS TO THE CHEMISTRY AND TESTS OF THE PHARMACOPŒIA.

CHEMICAL DEFINITIONS.

An Element is a substance which cannot be resolved into any simpler form of matter, at least by any known means. There are about sixty-three elements; of these, thirty-nine are used in medicine and pharmacy.

An Atom is the smallest particle to which an element can be reduced; or is the smallest particle of an element which can exist in combination with another element.

Atomic Weight is the relative weights of the atoms of the various elements, compared with the weight of an atom of hydrogen, which, being the lightest body known is taken as the standard. Thus, when it is said that the atomic weight of oxygen is 16, that means that its atom is sixteen times heavier than an atom of hydrogen; the atomic weight of nitrogen is 14, meaning that its atom is fourteen times heavier than one of hydrogen. The atomic weight of a compound is the sum of the atomic weights of the

elements composing it. Thus the atomic weight of water is 18, being made up of 2 atoms of hydrogen, each = 1, and one atom of oxygen = 16; 16 + 2 = 18.

A Molecule is the smallest particle of an element which can exist in a free state. An atom, as such, cannot exist alone, but unites with another atom; this constitutes a molecule, and molecules joined together form bodies. Thus $H + H = H_2$; this constituting a molecule of hydrogen.

A Chemical Compound is a substance composed of two or more elements held together by chemical affinity.

Chemical Affinity, or chemical force, are names applied to the power which holds together the elements in a molecule.

A Mechanical Mixture of substances is one in which each ingredient retains its properties.

A Chemical Symbol is a capital letter, as K, or a capital and one small letter, as Li. It has four functions, viz.:—

(1) It is short-hand for the name of the element.

(2) It represents one atom of the element.

(3) It stands for the atomic weight of the element.

(4) Symbols represent single and equal volumes of gaseous elements.

Thus the letter O stands for oxygen; it represents one atom of it, it stands for its atomic weight 16, and it represents a single volume.

A Chemical Formula represents a molecule either of an element or a compound. It also has four functions, viz.:—

(1) It indicates the names of the elements in the molecule.

(2) It shows the number of atoms in the molecule.

(3) It represents the molecular weight of the compound.

(4) In bodies capable of being volatilised it represents two volumes of the substance in the state of vapour.

Thus H_2SO_4 indicates the names of the elements in sulphuric acid; it shows the number of atoms in its molecule, it represents its molecular weight, and stands for two volumes of it in the gaseous state.

A Chemical Equation is a collection of symbols and formula so placed on paper as to represent the condition of things previous to and after chemical change has taken place. Thus,

$$\underset{\text{Zinc.}}{Zn} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{H_2SO_4} = \underset{\substack{\text{Sulphate of}\\ \text{zinc.}}}{ZnSO_4} + \underset{\text{Hydrogen.}}{2H}$$

constitutes a chemical equation; the symbols on the left hand side of the sign of equality picture the state of things previous to the occurrence of chemical action; those on the right give the condition after reaction.

A Solid is a substance the molecules of which are

more or less immobile, though probably not in absolute contact.

A Liquid is a substance the molecules of which so freely move about each other, that it readily assumes and retains the form of any vessel in which it is placed.

A Gas is a substance in which the molecules are so separated that they seem to have lost all attraction to one another, and to have acquired such a property of repulsion, that the only obstacle to their still further separation is the pressure of the surrounding matter.

An Amalgam is the term applied to the combination of mercury with one or more other metals.

An Alloy is a combination of metals into which mercury does not enter.

LAWS OF CHEMICAL COMBINATION.

1st. The law of **Constant Proportion.**—The same substance always contains the same elements united in the same proportions. Example: Sulphuric acid, H_2SO_4, always contains two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen.

2nd. The law of **Multiple Proportion.**—When two elements unite in more than one proportion they do so in some simple multiple of that proportion. Example: Nitrogen with oxygen forms five com-

pounds, the amount of oxygen in each increasing by a simple multiple of its amount in the first compound, thus :—

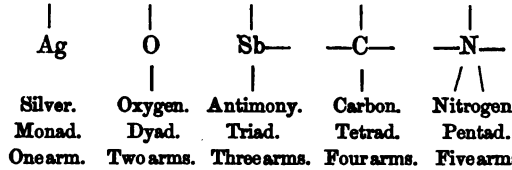
Nitrous Oxide, N_2O,	in the proportion of	28 to 16.
Nitric Oxide, N_2O_2,	do.	28 ,, 32.
Nitrous Anhydride, N_2O_3,	do.	28 ,, 48.
Nitric Peroxide, N_2O_4,	do.	28 ,, 64.
Nitric Anhydride, N_2O_5,	do.	28 ,, 80.

3rd. The law of **Reciprocal Proportion**.—The proportions in which two elements unite with a third are the proportions in which they unite with each other.

QUANTIVALENCE.

Atomicity or Quantivalence means the power possessed by an element of entering into combination with hydrogen or displacing it from its compounds. If an atom of an element displaces or combines with one atom of hydrogen, it is termed a **monad**; if it combines with or displaces two atoms of hydrogen, it is termed a **dyad**; if it combines with or displaces three atoms of hydrogen, it is termed a **triad**. In the same manner we have **tetrads, pentads,** and **hexads.** Quantivalence may be graphically portrayed by representing the atoms as having arms; and these, unable to remain unoccupied, attach themselves to the arms of the atoms of some other element, or to those of

their own. In the diagram below the arms are represented by lines drawn from the symbols.



Silver.	Oxygen.	Antimony.	Carbon.	Nitrogen.
Monad.	Dyad.	Triad.	Tetrad.	Pentad.
One arm.	Two arms.	Three arms.	Four arms.	Five arms.

Thus a substance having one arm is called a monad; if two, a dyad; and so on. All elements, with exception of hydrogen, may exhibit different degrees of quantivalence. From this fact arise two classes of salts, viz. *per* and *proto*, or *ic* and *ous*. Thus, taking for example iron, acting in a dyad capacity, it forms proto or ferrous salts, as protosulphate or ferrous sulphate, $FeSo_4$; acting as a triad, it forms per or ferric salts, as persulphate or ferric sulphate, $Fe_2(SO_4)_3$. Mercury likewise forms two classes of salts; as a monad, mercurous, as mercurous chloride, HgCl; as a dyad, mercuric, as mercuric chloride, $HgCl_2$.

Groups of elements likewise possess quantivalence and are termed **Compound Radicals**; of these there are two varieties, viz., **Acidulous Radicals** and **Basylous Radicals**. *An acidulous compound radical* is a group of elements capable of combining with hydrogen to form an acid, or with metals to form salts. Thus NO_3, an acidulous radical, united with hydro-

gen, forms nitric acid; it is also called a monad radical because it unites with but one atom of hydrogen. A *compound basylous radical* is a group of elements capable of displacing the hydrogen from an acid, thus forming a salt. Take, for example, Ammonium, NH_4: this by displacing the hydrogen from hydrochloric acid, HCl, becomes chloride of ammonium, NH_4Cl. It also is called a monad radical, because it displaces but one atom of hydrogen.

The following is a list of the **Acidulous** and **Basylous Radicals** of the Pharmacopœia, with their quantivalence.

ACIDULOUS RADICALS.

Monads.

Acetates, $C_2H_3O_2$.
Bromides, Br.
Chlorides, Cl.
Iodides, I.
Cyanides, CN.
Hydrates, HO.
Nitrates, NO_3.
Chlorates, ClO_3.

Dyads.

Oxides, O.
Sulphides, S.
Sulphites, SO_3.
Sulphates, SO_4.
Carbonates, CO_3.
Oxalates, C_2O_4.
Tartrates, $C_4H_4O_6$.

Triads.

Citrates, $C_6H_5O_7$.
Phosphates, PO_4.
Borates, BO_3.
Arseniates, AsO_4.

Tetrad.

Ferrocyanides, $FeCy_6$.

Hexad.

Ferridcyanides, Fe_2Cy_6.

BASYLOUS RADICALS.

Monads.

Hydrogen, H.
Lithium, Li.
Sodium, Na.
Silver, Ag.
Potassium, K.
Ammonium, NH_4.

Dyads.

Zinc, Zn.
Oxygen, O.
Cadmium, Cd.
Lead, Pb.
Magnesium, Mg.
Barium, Ba.
Calcium, Ca.
Copper, Cu.
Mercury, Hg.
Cerium, Ce.

Triads.

Gold, Au.
Bismuth, Bi.
Antimony, Sb.

Tetrads.

Iron, Fe.
Aluminium, Al.
Platinum, Pt.

Hexad.

Chromium, Cr.

ACIDS, BASES, SALTS, AND ANHYDRIDES.

An Acid is a hydrogen salt, the hydrogen being replaceable by a base. Acids are called monatomic if they contain one atom of hydrogen—as nitric acid, HNO_3; diatomic, if they contain two atoms of hydrogen—as sulphuric acid, H_2SO_4; triatomic, if they contain three atoms of hydrogen—as citric acid, $H_3C_6H_5O_7$. The acids of the Pharmacopœia are divided into two classes, viz., **Mineral and Vegetable**, according as they are derived from these kingdoms in nature.

A Base is an element capable of displacing the hydrogen from an acid, or combining with an acidulous radical to form a salt. All the elements, as silver, etc., may thus be termed bases.

A Salt is a compound formed either by the displacement of the hydrogen from an acid by a base, or by the direct union of a base with an acidulous radical, There are two classes of salts, viz., **Acid** or **Bisalts**, and **Normal** or **Neutral**, *an acid or bisalt* is one in which only a part of the hydrogen of the acid has been displaced by a base. Thus bicarbonate, or acid carbonate of potash, $KHCO_3$, may be considered as true carbonic acid, H_2CO_3, one atom of whose H has been replaced by one atom of K. A *normal or neutral salt* is one in which the whole of the hydrogen has been replaced by a base; thus carbonate or neutral carbonate of potash, K_2CO_3, may be considered as carbonic acid, H_2CO_3, the entire of whose H has been replaced by K.

Anhydrides are groups of elements capable of existing in a free state; of uniting with water to form acids; or with oxides of bases to form salts. The following are the principal anhydrides. It should be noticed that some of these, as CO_2, are often incorrectly termed acids.

Carbonic Anhydride,		CO_2.
Nitric	,,	N_2O_5.
Nitrous	,,	N_2O_3.

Arsenious Anhydride, As_2O_3.
Sulphuric ,, SO_3.
Sulphurous ,, SO_2.
Phosphoric ,, P_2O_5.

I will now ask the student (who has carefully read over these definitions, and committed to memory the lists of quantivalence) to write down the formula for nitrate of silver—remembering that the symbol for silver is Ag, that it is a monad base, that NO_3 is the symbol for the monad acidulous radical of an nitrate, and that single atoms of monads unite to form compounds. The answer cannot be for a moment doubtful. The formula for nitrate of silver must be $AgNO_3$. What is the formula for sulphate of potash?—K being the symbol for the monad potassium, SO_4 being the symbol for the dyad acidulous radical of a sulphate, and a dyad entering into combination with two atoms of monad. The formula for sulphate of potash must be K_2SO_4. A little chemical gymnastics of this kind daily, will do more than anything else that I know of, to facilitate the students acquiring a sound knowledge of the composition of the salts of the Pharmacopœia.

An Equation is to be read thus—taking for example the reaction which occurs in making hydrogen gas.

$$\underset{\text{Zinc.}}{Zn} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{H_2SO_4} = \underset{\substack{\text{Sulphate}\\ \text{of zinc.}}}{ZnSO_4} + \underset{\text{Hydrogen.}}{H_2}$$

Zinc and sulphuric acid yield sulphate of zinc and hydrogen gas.

If the name of an acid ends in *ic*, its salts will end in *ate*—as sulphuric acid, sulphate; if the acid ends in *ous*, its salts will end in *ite*—as sulphurous acid, sulphite.

GASES.

Oxygen, O.

Made by heating chlorate of potash.

$$\underset{\text{Chlorate of potash.}}{KClO_3} + \text{Heat} = \underset{\text{Chloride of potash.}}{KCl} + \underset{\text{Oxygen.}}{O_3}$$

Hydrogen, H.

Made by acting on zinc with sulphuric acid

$$\underset{\text{Zinc.}}{Zn} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Sulphate of zinc.}}{ZnSO_4} + \underset{\text{Hydrogen.}}{H_2}$$

Nitrogen, N.

Made by burning phosphorus in a bell-jar filled with air, the mouth of which is placed in a vessel full of water. The phosphorus here unites with the oxygen of the air, forming phosphorus pentoxide, and leaving its nitrogen free.

ACIDS.

Acetic Acid, $HC_2H_3O_2$.

Is made by the destructive distillation of wood,

and treating the distillate with carbonate of soda and sulphuric acid, thus:

$$\underset{\text{Acetate of sodium.}}{2NaC_2H_3O_2} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{H_2SO_4} = \underset{\text{Acetic acid.}}{2HC_2H_3O_2} + \underset{\substack{\text{Sulphate of}\\\text{sodium.}}}{Na_2SO_4}$$

Citric Acid, $H_3C_6H_5O_7$.

Made by acting on lemon juice with prepared chalk and sulphuric acid, thus:

First stage:

$$\underset{\substack{\text{Citric acid}\\\text{impure.}}}{2H_3C_6H_5O_7} + \underset{\substack{\text{Carbonate}\\\text{of calcium.}}}{3CaCo_3} = \underset{\substack{\text{Citrate of}\\\text{calcium.}}}{Ca_3 2C_6H_5O_7} + \underset{\text{Water.}}{3H_2O} + \underset{\substack{\text{Carbonic}\\\text{acid gas.}}}{3Co_2}$$

Second stage:

$$\underset{\substack{\text{Citrate of}\\\text{calcium.}}}{Ca_3 2C_6H_5O_7} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{3H_2SO_4} = \underset{\substack{\text{Citric acid,}\\\text{pure.}}}{2H_3C_6H_5O_7} + \underset{\substack{\text{Sulphate of}\\\text{calcium.}}}{3CaSO_4}$$

Hydrochloric Acid, HCl.

Made by acting on chloride of sodium with sulphuric acid, thus:

$$\underset{\substack{\text{Chloride}\\\text{of sodium.}}}{NaCl} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{H_2SO_4} = \underset{\substack{\text{Hydrochloric}\\\text{acid.}}}{HCl} + \underset{\substack{\text{Acid sulphate}\\\text{of sodium.}}}{NaHSO_4}$$

Hydrocyanic Acid, HCN.

Made by heating ferrocyanide of potassium with sulphuric acid, thus:

$$\underset{\substack{\text{Ferrocyanide of}\\\text{potassium.}}}{2K_4FeC_6N_6} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{6H_2SO_4} = \underset{\substack{\text{Hydrocyanic}\\\text{acid.}}}{6HCN} + \underset{\substack{\text{Acid Sulphate}\\\text{of potassium.}}}{6KHSO_4} + \underset{\substack{\text{Everitt's yellow salt.}}}{FeK_2FeC_6N_6}$$

Nitric Acid, HNO_3.

Made by acting upon nitrate of potash or soda with sulphuric acid.

$$\underset{\text{Nitrate of potash.}}{KNO_3} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Nitric acid.}}{HNO_3} + \underset{\text{Acid Sulphate of potassium.}}{KHSO_4}$$

Phosphoric Acid, H_3PO_4.

Made by boiling phosphorus with nitric acid and water.

$$\underset{\text{Phosphorus.}}{12P} + \underset{\text{Nitric acid.}}{20HNO_3} + \underset{\text{Water.}}{8H_2O} = \underset{\text{Phosphoric acid.}}{12H_3PO_4} + \underset{\text{Nitric oxide.}}{20NO}$$

Sulphuric Acid, H_2SO_4.

Made by the combustion of sulphur and oxidation of the resulting sulphurous acid by means of nitrous vapours and steam.

First stage:

$$\underset{\text{Sulphur.}}{S} + \text{Heat} = \underset{\text{Sulphurous acid gas.}}{SO_2}$$

Second stage:

$$\underset{\text{Sulphurous acid gas.}}{SO_2} + \underset{\text{Steam.}}{H_2O} = \underset{\text{Sulphurous acid.}}{H_2SO_3}$$

Third stage:

$$\underset{\text{Sulphurous acid.}}{H_2SO_3} + \underset{\text{Nitric peroxide.}}{NO_2} = \underset{\text{Sulphuric acid.}}{H_2SO_4} + \underset{\text{Nitric oxide.}}{NO}$$

Sulphurous Acid, H_2SO_3.

Made with sulphuric acid, wood charcoal, and water.

First stage:

$$\underset{\text{Sulphuric acid.}}{4H_2SO_4} + \underset{\text{Charcoal.}}{C_2} = \underset{\text{Carbonic acid.}}{2CO_2} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Sulphurous acid gas.}}{4SO_2}$$

Second stage:

$$\underset{\text{Sulphurous acid gas.}}{SO_2} + \underset{\text{Water.}}{H_2O} = \underset{\text{Sulphurous acid.}}{H_2SO_3}$$

Tartaric Acid, $H_2C_4H_4O_6$.

Made by acting on acid tartrate of potash with prepared chalk, chloride of calcium, and sulphuric acid.

First stage:

$$\underset{\text{Acid tartrate of potash.}}{2KHC_4H_4O_6} + \underset{\text{Prepared chalk.}}{CaCO_3} = \underset{\text{Tartrate of potash.}}{K_2C_4H_4O_6} + \underset{\text{Tartrate of lime.}}{CaC_4H_4O_6} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Second stage:

$$\underset{\text{Tartrate of potash.}}{K_2C_4H_4O_6} + \underset{\text{Chloride of calcium.}}{CaCl_2} = \underset{\text{Tartrate of lime.}}{CaC_4H_4O_6} + \underset{\text{Chloride of potassium.}}{2KCl}$$

Third stage:

$$\underset{\text{Tartrate of lime.}}{CaC_4H_4O_6} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Tartaric acid.}}{H_2C_4H_4O_6} + \underset{\text{Sulphate of lime.}}{CaSO_4}$$

Arsenious Acid, As_2O_3.

Made by roasting arsenical ores, (arsenio-sulphide of iron) and purified by sublimation. Arsenicum is obtained by heating As_2O_3 in a test tube with dry

charcoal; the carbon here unites with the oxygen of the arsenious acid, the metal being deposited on the sides of the tube.

Carbonic Acid, CO_2.

Made by acting on carbonate of lime with hydrochloric acid.

$$\underset{\text{Carbonate of lime.}}{CaCO_3} + \underset{\text{Hydrochloric acid.}}{2HCl} = \underset{\text{Chloride of calcium.}}{CaCl_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

SALTS.

AMMONIUM, HH_4.

Chloride of Ammonium, NH_4Cl.

Made by neutralising liquor ammonia with hydrochloric acid.

$$\underset{\text{Liquor ammonia.}}{NH_4HO} + \underset{\text{Hydrochloric acid.}}{HCl} = \underset{\text{Chloride of ammonium.}}{NH_4Cl} + \underset{\text{Water.}}{H_2O}$$

Benzoate of Ammonia, $NH_4C_7H_5O_2$.

Made by dissolving benzoic acid in strong liquor ammonia.

$$\underset{\text{Benzoic acid.}}{HC_7H_5O_2} + \underset{\text{Liquor ammonia.}}{NH_4HO} = \underset{\text{Benzoate of ammonia.}}{NH_4C_7H_5O_2} + \underset{\text{Water.}}{H_2O}$$

Carbonate of Ammonia, $(NH_4HCO_3)_2NH_4NH_2CO_2$.

Made by subliming together chloride of ammonium and carbonate of lime.

$$\underset{\text{Chloride of ammonium.}}{6NH_4Cl} + \underset{\text{Carbonate of lime.}}{3CaCO_3} = \underset{\text{Carbonate of ammonium and carbamate of ammonium.}}{(NH_4HCO_3)_2NH_4NH_2CO_2} + \underset{\text{Ammonia gas.}}{2NH_3} + \underset{\text{Chloride of lime.}}{3CaCl_2} + \underset{\text{Water.}}{H_2O}$$

Phosphate of Ammonia, $(NH_4)_2HPO_4$.

Made by adding phosphoric acid to liquor ammonia.

$$\underset{\text{Liquor ammonia.}}{2NH_4HO} + \underset{\text{Phosphoric acid.}}{H_3PO_4} = \underset{\text{Phosphate of ammonia.}}{(NH_4)_2HPO_4} + \underset{\text{Water.}}{2H_2O}$$

Bromide of Ammonium, NH_4Br.

Made by adding hydrobromic acid to liquor ammonia.

$$\underset{\text{Liquor ammonia.}}{NH_4HO} + \underset{\text{Hydrobromic acid.}}{HBr} = \underset{\text{Bromide of ammonium.}}{NH_4Br} + \underset{\text{Water.}}{H_2O}$$

Liquor Ammonia Fortior.

Made by heating together chloride of ammonium and slaked lime. NH_3 is thus produced, which when dissolved in water forms strong solution of ammonia.

$$\underset{\text{Chloride of ammonium.}}{2NH_4Cl} + \underset{\text{Slaked lime.}}{Ca2HO} = \underset{\text{Chloride of calcium.}}{CaCl_2} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Ammonia gas.}}{2NH_3}$$

ANTIMONY, Sb.

Liquor Antimonii Chloridi, $SbCl_3$.

Made by acting on black antimony with hydrochloric acid.

$$\underset{\text{Black antimony.}}{Sb_2S_3} + \underset{\text{Hydrochloric acid.}}{6HCl} = \underset{\text{Chloride of antimony.}}{2SbCl_3} + \underset{\text{Sulphuretted hydrogen.}}{3H_2S}$$

Oxide of Antimony, Sb_2O_3.

Made by acting on a solution of chloride of antimony with carbonate of soda.

$$\underset{\text{Oxychloride of antimony.}}{2SbCl_3 5Sb_2O_3} + \underset{\text{Carbonate of soda.}}{3Na_2Co_3} = \underset{\text{Oxide of antimony.}}{6Sb_2O_3} + \underset{\text{Chloride of sodium.}}{6NaCl} + \underset{\text{Carbonic acid.}}{3CO_2}$$

Tartarated Antimony, $KSbC_4H_4O_7H_2O$.

Made by mixing together oxide of antimony and acid tartrate of potash, then boiling.

$$\underset{\text{Oxide of antimony.}}{Sb_2O_3} + \underset{\text{Acid tartrate of potash.}}{2KHC_4H_4O_6} = \underset{\text{Tartar emetic.}}{2KSbC_4H_4O_7} + \underset{\text{Water.}}{H_2O}$$

SILVER, Ag.

Nitrate of Silver, $AgNO_3$.

Made by acting on purified silver with nitric acid.

$$\underset{\text{Silver.}}{6Ag} + \underset{\text{Nitric acid.}}{8HNO_3} = \underset{\text{Nitrate of silver.}}{6AgNO_3} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitric oxide.}}{2NO}$$

Oxide of Silver, Ag_2O.

Made by adding a solution of lime water to nitrate of silver.

$$\underset{\text{Nitrate of silver.}}{2AgNO_3} + \underset{\text{Lime water.}}{Ca2HO} = \underset{\text{Oxide of silver.}}{Ag_2O} + \underset{\text{Nitrate of calcium.}}{Ca2NO_3} + \underset{\text{Water.}}{H_2O}$$

BISMUTH, Bi.

Carbonate of Bismuth, $Bi_2O_2CO_3$.

Made by acting on nitrate of bismuth with carbonate of ammonia.

$$\underset{\text{Nitrate of bismuth.}}{4(Bi3NO_3)} + \underset{\text{Carbonate of ammonia.}}{3N_4H_{16}C_3O_8} = \underset{\text{Nitrate of ammonia.}}{12NH_4NO_3} + \underset{\text{Carbonate of bismuth.}}{2Bi_2O_2CO_3} + \underset{\text{Carbonic acid.}}{7CO_2}$$

Subnitrate of Bismuth, $BiONO_3H_2O$.

Made by pouring a solution of nitrate of bismuth into water.

$$\underset{\text{Nitrate of bismuth.}}{Bi3NO_3} + \underset{\text{Water.}}{H_2O} = \underset{\text{Subnitrate of bismuth.}}{BiONO_3} + \underset{\text{Nitric acid.}}{2HNO_3}$$

BROMINE, Br.

Made by passing chlorine gas into sea water. This sets free the bromine, which is then taken up by shaking with ether. Subsequent purification is required, brought about by converting the bromine into bromide of potassium, and treating this with black oxide of manganese and sulphuric acid.

The following reaction represents the changes which occur during the last stage of the process.

$$\underset{\text{Bromide of potash.}}{2KBr} + \underset{\text{Black oxide of manganese.}}{MuO_2} + \underset{\text{Sulphuric acid.}}{2H_2SO_4} = \underset{\text{Sulphate of potash.}}{K_2SO_4} + \underset{\text{Sulphate of manganese.}}{MuSO_4} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Bromine.}}{2Br.}$$

CALCIUM, Ca.

Chloride of Calcium, $CaCl_2$.

Made by acting on carbonate of lime with hydrochloric acid.

$CaCO_3$	+	$2HCl$	=	$CaCl_2$	+	H_2O	+	CO_2
Carbonate of lime.		Hydrochloric acid.		Chloride of calcium.		Water.		Carbonic acid.

Precipitated Carbonate of Lime, $CaCO_3$.

Made by mixing together a solution of chloride of calcium and carbonate of soda.

$CaCl_2$	+	Na_2CO_3	=	$CaCO_3$	+	$2NaCl$
Chloride of calcium.		Carbonate of soda.		Carbonate of lime.		Chloride of sodium.

Slaked Lime, Ca2HO.

CaO	+	H_2O	=	$Ca2HO$
Lime.		Water		Slaked lime.

Phosphate of Lime, Ca_32PO_4.

Made by acting on bone ash with hydrochloric acid and solution of ammonia.

First stage:

Ca_32PO_4	+	$4HCl$	=	CaH_42PO_4	+	$2CaCl_2$
Phosphate of lime, impure.		Hydrochloric acid.		Acid phosphate of lime.		Chloride of calcium.

Second stage:

CaH_42PO_4	+	$2CaCl_2$	+	$4NH_4HO$	=	Ca_32PO_4	+
Acid phosphate of lime.		Chloride of calcium.		Liquor ammonia.		Phosphate of lime, pure.	

$4NH_4Cl$	+	$4H_2O$
Chloride of ammonium.		Water.

Chlorinated Lime, $Ca2ClO, CaCl_2$

Made by passing chlorine gas over slaked lime.

$$\underset{\text{Slaked lime.}}{2Ca2HO} + \underset{\text{Chlorine.}}{4Cl} = \underset{\text{Water.}}{2H_2O} + \underset{\text{Chlorinated lime.}}{Ca2ClO,CaCl_2}$$

COPPER, Cu.

Sulphate of Copper, $CuSO_4 5H_2O$.

Made by acting on copper with sulphuric acid.

$$\underset{\text{Copper.}}{2Cu} + \underset{\text{Sulphuric acid.}}{4H_2SO_4} = \underset{\text{Sulphate of copper.}}{2CuSO_4} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Sulphurous acid.}}{2SO_2}$$

Chlorine, Cl.

Made by acting on black oxide of manganese with hydrochloric acid.

$$\underset{\text{Black oxide manganese.}}{MnO_2} + \underset{\text{Hydrochloric acid.}}{4HCl} = \underset{\text{Chloride of manganese.}}{MnCl_2} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Chlorine.}}{Cl_2}$$

IRON, Fe.

(Ferrous Salts.)

Arseniate of Iron, $Fe_3(AsO_4)_2$.

Made by acting on sulphate of iron with arseniate and acetate of soda. Acetate of soda is here used to prevent the presence of free sulphuric acid.

$$\underset{\text{Sulphate of iron.}}{3FeSO_4} + \underset{\text{Arseniate of soda.}}{2Na_2HAsO_4} + \underset{\text{Acetate of soda.}}{2NaC_2H_3O_2} =$$

$$\underset{\text{Arseniate of iron.}}{Fe_3(AsO_4)_2} + \underset{\text{Sulphate of soda.}}{3Na_2SO_4} + \underset{\text{Acetic acid.}}{2HC_2H_3O_2}$$

Carbonate of Iron, $FeCO_3$.

Made by acting on sulphate of iron with carbonate of ammonia.

$$\underset{\text{Sulphate of iron.}}{FeSO_4} + \underset{\text{Carbonate of ammonia.}}{(NH_4)_2CO_3} = \underset{\text{Carbonate of iron.}}{FeCO_3} + \underset{\text{Sulphate of ammonium.}}{(NH_4)_2SO_4}$$

Sulphate of Iron, $FeSO_4$.

Made by acting on iron wire with sulphuric acid.

$$\underset{\text{Iron.}}{2Fe} + \underset{\text{Sulphuric acid.}}{2H_2SO_4} = \underset{\text{Sulphate of iron.}}{2FeSO_4} + \underset{\text{Hydrogen.}}{4H}$$

Phosphate of Iron, Fe_32PO_4.

Made by acting on sulphate of iron with phosphate and acetate of soda. Acetate of soda is here used to prevent the presence of free sulphuric acid.

$$\underset{\text{Sulphate of iron.}}{3FeSO_4} + \underset{\text{Phosphate of soda.}}{2Na_2HPO_4} + \underset{\text{Acetate of soda.}}{2NaC_2H_3O_2} = \underset{\text{Phosphate of iron.}}{Fe_32PO_4}$$

$$+ \underset{\text{Sulphate of soda.}}{3Na_2SO_4} + \underset{\text{Acetic acid.}}{2HC_2H_3O_2}$$

Iodide of Iron, FeI_2.

Made by boiling iron wire with iodine and water.

$$\underset{\text{Iron.}}{Fe} + \underset{\text{Iodine.}}{I_2} = \underset{\text{Iodide of iron}}{FeI_2}$$

FERRIC SALTS.

Liquor Ferri Perchloridi Fort.

Made by acting on iron wire with hydrochloric and nitric acid.

First stage:

$$\underset{\text{Iron.}}{2Fe} + \underset{\text{Hydrochloric acid.}}{4HCl} = \underset{\text{Ferrous chloride.}}{2FeCl_2} + \underset{\text{Hydrogen.}}{4H}$$

Second stage:

$$\underset{\text{Ferrous chloride.}}{6FeCl_2} + \underset{\text{Hydrochloric acid.}}{6HCl} + \underset{\text{Nitric acid.}}{2HNO_3} = \underset{\text{Ferric chloride.}}{3Fe_2Cl_6} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitric oxide.}}{2NO}$$

Liquor Ferri Pernitratis.

Made by acting on iron wire with nitric acid.

$$\underset{\text{Iron.}}{Fe_2} + \underset{\text{Nitric acid.}}{8HNO_3} = \underset{\text{Pernitrate of iron.}}{Fe_2 6HNO_3} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitric oxide.}}{2NO}$$

Liquor Ferri Persulphatis.

Made by acting on ferrous sulphate with sulphuric and nitric acid.

$$\underset{\text{Ferrous sulphate.}}{6FeSO_4} + \underset{\text{Sulphuric acid.}}{3H_2SO_4} + \underset{\text{Nitric acid.}}{2HNO_3} = \underset{\text{Ferric sulphate.}}{3(Fe_2 3SO_4)} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitric oxide.}}{2NO}$$

Acetate of Iron, $Fe_2 6C_2H_3O_2$.

Made by acting on a solution of persulphate of iron with acetate of potash.

$$\underset{\text{Ferric sulphate.}}{Fe_2 3SO_4} + \underset{\text{Acetate of potash.}}{6KC_2H_3O_2} = \underset{\text{Sulphate of potash.}}{3K_2SO_4} + \underset{\text{Acetate of iron.}}{Fe_2 6C_2H_3O_2}$$

Moist Peroxide of Iron, $Fe_2 6HO$.

Made by acting on a solution of the persulphate of iron with a solution of soda.

$$Fe_2 3SO_4 + 6NaHO = Fe_2 6HO + 3Na_2SO_4$$

Ferric sulphate. Soda. Moist peroxide. Sulphate of soda.

Dried Peroxide of Iron, $Fe_2O_2 2HO$.

Made by drying the moist peroxide of iron.

$$Fe_2 6HO + Heat = Fe_2O_2 2HO + 2H_2O$$

Moist peroxide. Dried peroxide. Water.

Magnetic Oxide of Iron, $Fe_3 8HO$.

Made by acting on sulphate of iron with the solution of the persulphate of iron and solution of soda.

$$Fe_2 3SO_4 + FeSO_4 + 8NaHO = Fe_3 8HO + 4Na_2SO_4$$

Ferric sulphate. Ferrous sulphate. Soda. Magnetic oxide. Sulphate of soda.

Reduced Iron, Fe.

Made by passing hydrogen gas over hydrated peroxide of iron.

$$Fe_2O_3 + 6H = 2Fe + 3H_2O$$

Ferric oxide. Hydrogen. Iron. Water.

MERCURY, Hg.

Green or Mercurous Iodide, HgI.

Made by triturating iodine with mercury.

$$Hg + I = HgI$$

Mercury. Iodine. Mercurous iodide.

Red or Mercuric Iodide, HgI_2.

Made by mixing together solutions of perchloride of mercury and iodide of potassium.

$2KI$	+	$HgCl_2$	=	HgI_2	+	$2KCl$
Iodide of potassium.		Perchloride of mercury.		Mercuric iodide.		Chloride of potassium.

Calomel or Mercurous Chloride, HgCl.

Made by acting on mercury and sulphate of mercury with chloride of sodium. The mercury is here used to convert the mercurous sulphate into the mercuric.

First stage:

Hg	+	$HgSO_4$	=	Hg_2SO_4
Mercury.		Mercuric sulphate.		Mercurous sulphate.

Second stage:

Hg_2SO_4	+	$2NaCl$	=	$2HgCl$	+	Na_2SO_4
Mercurous sulphate.		Chloride of sodium.		Calomel.		Sulphate of soda.

Corrosive Sublimate, Mercuric Chloride, $HgCl_2$.

Made by acting on sulphate of mercury with chloride of sodium and black oxide of manganese. The use of the latter is to convert any calomel that may be formed into corrosive sublimate.

$HgSO_4$	+	$2NaCl$	=	$HgCl_2$	+	Na_2SO_4
Mercuric sulphate.		Chloride of sodium.		Corrosive sublimate.		Sulphate of soda.

Red Oxide of Mercury, HgO.

Made by acting on mercury with nitric acid: this

forms nitrate of mercury, which when heated yields the red oxide.

$$2Hg2NO_3 + \text{Heat} = 2HgO + 4NO_2 + O_2$$

Mercuric nitrate. — Oxide of mercury. — Nitric peroxide. — Oxygen.

Sulphate of Mercury, $HgSO_4$.

Made by acting on mercury with sulphuric acid.

$$Hg + 2H_2SO_4 = HgSO_4 + 2H_2O + SO_2$$

Mercury. — Sulphuric acid. — Mercuric sulphate. — Water. — Sulphurous acid.

Ammoniated Mercury, NH_2HgCl.

Made by acting on perchloride of mercury with solution of ammonia.

$$HgCl_2 + 2NH_4HO = NH_2HgCl + NH_4Cl + 2H_2O$$

Mercuric chloride. — Ammonia. — White precipitate. — Chloride of ammonium. — Water.

Lotio Nigra, Hg_2O, dissolved in Water.

Made with calomel and lime water.

$$2HgCl + Ca2HO = Hg_2O + CaCl_2 + H_2O$$

Calomel. — Lime water. — Mercurous oxide. — Chloride of calcium. — Water.

Lotio Flava, HgO, dissolved in Water.

Made with corrosive sublimate and lime water.

$$HgCl_2 + Ca2HO = HgO + CaCl_2 + H_2O$$

Mercuric chloride. — Lime water. — Mercuric oxide. — Chloride of calcium. — Water

IODINE, I.

Made from the ashes of sea-weeds, by treating them with water, black oxide of manganese, and

sulphuric acid. Iodine exists in the ashes as iodides of sodium, potassium, and magnesium.

$$\underset{\text{Iodide of sodium.}}{2NaI} + \underset{\text{Manganese dioxide.}}{MnO_2} + \underset{\text{Sulphuric acid.}}{2H_2SO_4} = \underset{\text{Sulphate of sodium.}}{Na_2SO_4} + \underset{\text{Sulphate of manganese.}}{MnSO_4} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Iodine.}}{2I}$$

LITHIUM, Li.

Citrate of Lithia, $Li_3C_6H_5O_7$.

Made by acting on carbonate of lithium with citric acid.

$$3Li_2CO_3 + 2H_3C_6H_5O_7 = 2Li_3C_6H_5O_7 + 3H_2O + 3CO_2$$

MAGNESIUM, Mg.

Sulphate of Magnesia, $MgSO_4 7H_2O$.

Made by treating the native carbonate of magnesium with sulphuric acid.

$$\underset{\text{Magnesite.}}{MgCO_3} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Sulphate of magnesia.}}{MgSO_4} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Carbonate of Magnesia, $MgCO_3 Mg2HO$.

Made by treating sulphate of magnesia with carbonate of soda. There are two kinds of this carbonate, viz., light and heavy. A similar reaction occurs during the manufacture of either kind.

$$\underset{\text{Sulphate of magnesia.}}{4MgSO_4} + \underset{\text{Carbonate of soda.}}{4Na_2CO_3} + \underset{\text{Water.}}{H_2O} = \underset{\text{Carbonate of magnesia.}}{3MgCO_3 Mg2HO} + \underset{\text{Sulphate of soda.}}{4Na_2SO_4} + \underset{\text{Carbonic acid.}}{CO_2}$$

Magnesia, MgO.

Made by heating the light or heavy carbonate of magnesia, according as light or heavy magnesia is required.

$$3MgCO_3Mg2HO + Heat = 4MgO + 3H_2O + 3CO_2$$

Carbonate of magnesia. — Magnesia. — Water. — Carbonic acid.

LEAD, Pb.

Acetate of Lead, $Pb2C_2H_3O_2$.

Made by acting on oxide of lead with acetic acid.

$$PbO + 2HC_2H_3O_2 = Pb2C_2H_3O_2 + H_2O$$

Oxide of lead. — Acetic acid. — Acetate of lead. — Water.

Iodide of Lead, PbI_2.

Made by acting on nitrate of lead with iodide of potassium.

$$Pb2NO_3 + 2KI = PbI_2 + 2KNO_3$$

Nitrate of lead. — Iodide of potassium. — Iodide of lead. — Nitrate of potash.

Nitrate of Lead, $Pb2NO_3$.

Made by acting on oxide of lead with nitric acid.

$$PbO + 2HNO_3 = Pb2NO_3 + H_2O$$

Oxide of lead. — Nitric acid. — Nitrate of lead. — Water.

POTASSIUM, K.

Liquor Potassæ.

Made by acting on carbonate of potash with

slaked lime; caustic potash is thus formed, which when dissolved in water forms liquor potassæ.

$$\underset{\text{Carbonate of potash.}}{K_2CO_3} + \underset{\text{Slaked lime.}}{Ca2HO} = \underset{\text{Caustic potash.}}{2KHO} + \underset{\text{Carbonate of calcium.}}{CaCO_3}$$

Acetate of Potash, $KC_2H_3O_2$.

Made by acting on carbonate of potash with acetic acid.

$$\underset{\text{Carbonate of potash.}}{K_2CO_3} + \underset{\text{Acetic acid.}}{2HC_2H_3O_2} = \underset{\text{Acetate of potash.}}{2KC_2H_3O_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic Acid.}}{CO_2}$$

Carbonate of Potash, K_2CO_3.

Obtained from wood-ashes by treating them with water; subsequently evaporating.

Bicarbonate of Potash, $KHCO_3$.

Made by passing carbonic acid gas into a solution of carbonate of potash.

$$\underset{\text{Carbonate of potash.}}{K_2CO_3} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2} = \underset{\text{Bicarbonate of potash.}}{2KHCO_3}$$

Chlorate of Potash, $KClO_3$.

Made by passing chlorine gas into a solution of caustic potash.

$$\underset{\text{Caustic potash.}}{6KHO} + \underset{\text{Chlorine.}}{6Cl} = \underset{\text{Chlorate of potash.}}{KClO_3} + \underset{\text{Chloride of potash.}}{5KCl} + \underset{\text{Water.}}{3H_2O}$$

Iodide of Potassium, KI.

Made by treating a solution of potash with iodine.

Iodate of potassium occurs during the process of manufacture; this is converted into the iodide by means of wood charcoal.

$$\underset{\text{Caustic potash.}}{6KHO} + \underset{\text{Iodine.}}{6I} = \underset{\text{Iodide of potassium.}}{5KI} + \underset{\text{Iodate of potash.}}{KIO_3} + \underset{\text{Water.}}{3H_2O}$$

The iodate is converted into the iodide, thus:

$$\underset{\text{Iodate of potash.}}{2KIO_3} + \underset{\text{Carbon.}}{6C} = \underset{\text{Iodide of potassium.}}{2KI} + \underset{\text{Carbonic Oxide.}}{6CO}$$

Bromide of Potassium, KBr.

Made by treating a solution of potash with bromine. Wood charcoal is here used to convert the bromate into the bromide; this it does by taking up oxygen same as in case of the iodate.

$$\underset{\text{Caustic potash.}}{6KHO} + \underset{\text{Bromine.}}{6Br} = \underset{\text{Bromide of potassium.}}{5KBr} + \underset{\text{Bromate of potassium.}}{KBrO_3} + \underset{\text{Water.}}{3H_2O}$$

Citrate of Potash, $K_3C_6H_5O_7$.

Made by acting on carbonate of potash with citric acid.

$$\underset{\text{Carbonate of potash.}}{3K_2CO_3} + \underset{\text{Citric acid.}}{2H_3C_6H_5O_7} = \underset{\text{Citrate of potash.}}{2K_3C_6H_5O_7} + \underset{\text{Water.}}{3H_2O} + \underset{\text{Carbonic acid.}}{3CO_2}$$

Tartrate of Potash, $K_2C_4H_4O_6$.

Made by neutralising acid tartrate of potash with carbonate of potash.

$$\underset{\text{Acid tartrate of potash.}}{2KHC_4H_4O_6} + \underset{\text{Carbonate of potash.}}{K_2CO_3} = \underset{\text{Tartrate of potash.}}{2K_2C_4H_4O_6} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Permanganate of Potash, $K_2Mn_2O_8$.

Made by fusing together caustic potash, chlorate of potash, and black oxide of manganese; this forms manganate of potash, which when boiled with water is converted into the permanganate.

$$3K_2MnO_4 + 2H_2O = K_2Mn_2O_8 + 4KHO + MnO_2$$

Manganate of potash. | Water. | Permanganate of potash. | Caustic potash. | Manganese dioxide.

Sulphate of Potash, K_2SO_4.

Made by neutralising the acid sulphate of potash left in the preparation of nitric acid with carbonate of potash.

$$2KHSO_4 + K_2CO_3 = 2K_2SO_4 + H_2O + CO_2$$

Acid sulphate of potash. | Carbonate of potash. | Sulphate of potash. | Water. | Carbonic acid.

SODIUM, Na.

Liquor Sodæ.

Made by acting on carbonate of soda with slaked lime; caustic soda is thus formed, which when dissolved in water forms liquor sodæ.

$$Na_2CO_3 + Ca2HO = 2NaHO + CaCO_3$$

Carbonate of soda. | Lime water. | Liquor sodæ. | Carbonate of lime.

Tartarated Soda, $KNaC_4H_4O_6$.

Made by acting on acid tartrate of potash with carbonate of soda.

$$Na_2CO_3 + 2KHC_4H_4O_6 = 2KNaC_4H_4O_6 + H_2O + CO_2$$

Carbonate of soda. | Acid tartrate of potash. | Tartarated soda. | Water. | Carbonic acid.

Acetate of Soda, $NaC_2H_3O_2$.

Made by acting on carbonate of soda with acetic acid.

$$\underset{\text{Carbonate of soda.}}{Na_2CO_3} + \underset{\text{Acetic acid.}}{2HC_2H_3O_2} = \underset{\text{Acetate of soda.}}{2NaC_2H_3O_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Arseniate of Soda, $Na_2HAsO_47H_2O$.

Made by heating together arsenious acid, nitrate of, and dried carbonate of soda; pyro-arseniate of soda is thus formed, which when heated with water yields arseniate of soda.

$$\underset{\text{Pyro-arseniate of soda.}}{Na_4As_2O_7} + \underset{\text{Water.}}{H_2O} = \underset{\text{Arseniate of soda.}}{2Na_2HAsO_47H_2O}$$

Carbonate of Soda, Na_2CO_3.

Obtained from the ashes of marine plants or by the chemical decomposition of chloride of sodium with sulphuric acid and carbonate of lime.

Bicarbonate of Soda, $KCHO_3$.

Made by passing carbonic acid into a solution of carbonate of soda.

$$Na_2CO_3 + H_2O + CO_2 = 2NaHCO_3$$

Phosphate of Soda, $Na_2HPO_412H_2O$.

Made by acting on bone-ash with sulphuric acid and carbonate of soda.

First stage:

$$\underset{\text{Bone ash.}}{Ca_32PO_4} + \underset{\text{Sulphuric acid.}}{2H_2SO_4} = \underset{\text{Acid phosphate of lime.}}{CaH_42PO_4} + \underset{\text{Sulphate of lime.}}{2CaSO_4}$$

Second stage:

$$\underset{\text{Acid phosphate of lime.}}{CaH_4 2PO_4} + \underset{\text{Carbonate of soda.}}{Na_2CO_3} = \underset{\text{Phosphate of soda.}}{Na_2HPO_4} + \underset{\text{Mono-calcic phosphate.}}{CaHPO_4} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Sulphate of Soda, $Na_2SO_4 10H_2O$.

Made by neutralising the acid sulphate of sodium left in the preparation of hydrochloric acid with carbonate of soda.

$$\underset{\text{Acid sulphate of soda.}}{2NaHSO_4} + \underset{\text{Carbonate of soda.}}{Na_2CO_3} = \underset{\text{Sulphate of soda.}}{2Na_2SO_4} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

ZINC, Zn.

Carbonate of Zinc, $ZnCO_3 2Zn$.

Made by acting on sulphate of zinc with carbonate of soda.

$$\underset{\text{Sulphate of zinc.}}{3ZnSO_4} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Carbonate of soda.}}{3Na_2CO_3} = \underset{\text{Carbonate of zinc.}}{ZnCO_3 2ZnH_2O_2} + \underset{\text{Sulphate of soda.}}{3Na_2SO_4} + \underset{\text{Carbonic acid.}}{CO_2}$$

Acetate of Zinc, $Zn2C_2H_3O_2 2HO_2$.

Made by acting on carbonate of zinc with acetic acid.

$$\underset{\text{Carbonate of zinc.}}{ZnCO_3 2ZnH_2O_2} + \underset{\text{Acetic acid.}}{6HC_2H_3O_2} = \underset{\text{Acetate of zinc.}}{3ZnC_2H_3O_2} + \underset{\text{Water.}}{5H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Chloride of Zinc, $ZnCl_2$.

Made by acting on granulated zinc with hydrochloric acid. Solution of chlorine and carbonate of zinc are used in making this salt for the purpose of getting rid of the iron and lead which exist as impurities in the granulated zinc. The chlorine converts the iron and lead into chlorides, the carbonate of zinc changes the iron chloride into ferric hydrate, and the lead chloride into the peroxide, itself becoming chloride of zinc.

$$\underset{\text{Zinc.}}{2Zn} + \underset{\text{Hydrochloric acid.}}{4HCl} = \underset{\text{Chloride of zinc.}}{2ZnCl_2} + \underset{\text{Hydrogen.}}{4H}$$

Sulphate of Zinc, $ZnSO_4 7H_2O$.

Made by acting on granuated zinc with sulphuric acid. Solution of chlorine and carbonate of zinc are used for the same purpose as in the making of the chloride. This is the general way of making hydrogen gas.

$$\underset{\text{Zinc.}}{Zn} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Sulphate of zinc.}}{ZnSO_4} + \underset{\text{Water.}}{2H}$$

Oxide of Zinc, ZnO.

Made by heating the carbonate of zinc.

$$\underset{\text{Carbonate of zinc.}}{ZnCO_3 2ZnH_2O_2} + \text{Heat} = \underset{\text{Oxide of zinc.}}{3ZnO} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Carbonic acid.}}{CO_2}$$

Valerianate of Zinc, $Zn2C_5H_9O_2$.

Made by acting on sulphate of zinc with valerianate of soda.

$$ZnSO_4 + 2NaC_5H_9O_2 = Na_2SO_4 + Zn2C_5H_9O_2$$

Sulphate of zinc. | Valerianate of soda. | Sulphate of soda. | Valerianate of zinc.

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Nitrate of Ammonia, NH_4NO_3.

Made by acting on carbonate of ammonia with nitric acid.

$$N_4H_{16}C_3O_8 + 4HNO_3 = 4NH_4NO_3 + 2H_2O + 3CO_2$$

Carbonate of ammonia. | Nitric acid. | Nitrate of ammonia. | Water. | Carbonic acid.

Oxide of Bismuth, Bi_2O_3.

Made by boiling a solution of subnitrate of bismuth with a solution of soda.

$$2BiONO_3 + 2NaHO = Bi_2O_3 + H_2O + 2NaNO_3$$

Subnitrate of bismuth. | Caustic soda. | Oxide of bismuth. | Water. | Nitrate of soda.

Yellow Oxide of Mercury, HgO.

Made by adding a solution of soda to perchloride of mercury.

$$HgCl_2 + 2NaHO = HgO + 2NaCl + H_2O$$

Perchloride of mercury. | Solution of soda. | Yellow oxide. | Chloride of sodium. | Water.

Hypophosphite of Lime, $Ca2PH_2O_2$.

Made by heating phosphorus with slaked lime.

$$8P + 3Ca2HO + 6H_2O = 3Ca2PH_2O_2 + 2PH_3$$

Phosphorus.	Slaked lime.	Water.	Phosphate of lime.	Phosphuretted hydrogen.

Hypophosphite of Soda, $NaPH_2O_2$.

Made by adding carbonate of sodium to a solution of hypophosphite of lime.

$$Ca2PH_2O_2 + Na_2CO_3 = 2NaPH_2O_2 + CaCO_3$$

Hypophosphite of lime.	Carbonate of soda.	Hypophosphite of soda.	Carbonate of lime.

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For purposes of analysis, the principal metallic bases are divided into five groups, viz.:—Silver group, Copper group, Iron group, Barium group, and Potassium group.

Silver Group.

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Copper Group.

Copper, Mercury (as a mercuric salt), **Bismuth, Arsenic,** and **Antimony**—all of which are precipitated as sulphides by sulphuretted hydrogen.

Iron Group.

Iron, Zinc, Aluminium, Manganese, and **Chromium,** all of which are precipitated by sulphide of ammonium as sulphides.

Barium Group.

Barium and **Calcium.** These are precipitated by carbonate of ammonium as carbonates.

Potassium Group.

Potassium, Magnesium, Sodium, and **Ammonium.** There is no common precipitant for this group; their presence is therefore determined by means of separate tests.

TESTS FOR THE METALS.

Metals.	*Tests.*
SILVER.	**Hydrochloric Acid** gives a white precipitate of chloride of silver, freely soluble in liquor ammonia. This serves to distinguish the chloride of silver from the cyanide, the latter being soluble with difficulty in liquor ammonia.
AMMONIUM.	Heated with **Liquor Potassæ** or **Liquor Sodæ**, it evolves ammonia gas, which is recognised by its smell.
ALUMEN.	With **Liquor Potassæ**, or **Liquor Sodæ**, gives a white precipitate, soluble in excess of the mixture, evolving ammonia, especially when heated.
ANTIMONY.	With **Sulphuretted Hydrogen**, gives a yellow precipitate of sulphide of antimony, soluble in boiling concentrated hydrochloric

Metals.	*Tests.*
ANTIMONY. (*continued*)	acid; this serves to distinguish it from arsenic, which also gives a yellow precipitate with sulphuretted hydrogen, but insoluble in hydrochloric acid. *See* Marsh's Test.
ARSENIC.	Thrown on a hot coal it evolves an alliaceous odour. Heated in a test tube with a fragment of charcoal, it sublimes and is deposited on the cool part of the tube as a dark mirror-like metallic incrustation. With **Ammonio Nitrate of Silver** it gives a canary yellow precipitate of arsenite of silver. With **Ammonio Sulphate of Copper** it gives Scheele's green. *See* Special Tests, p. 55.
BARIUM.	With **Sulphuric Acid** it gives a white precipitate of sulphate of barium, insoluble even in boiling nitric acid.
BISMUTH.	With **Sulphuretted Hydrogen,** gives a black precipitate of sulphide

Metals.	*Tests.*
BISMUTH. (*continued*)	of bismuth, insoluble when liquor ammonia and sulphydrate of ammonium have been added. This serves to distinguish between it and arsenic and antimony, which likewise give precipitates with sulphuretted hydrogen, but soluble in liquor ammonia and sulphide of ammonium.
CALCIUM.	With **Oxalate of Ammonium,** gives a white precipitate of oxalate of lime. With **Sulphuric Acid** it gives sulphate of lime; this being slightly soluble in water is not precipitated. This fact serves to distinguish lime from barium—barium sulphate being precipitated.
COPPER.	With **Ferrocyanide of Potassium,** gives a maroon red precipitate of ferrocyanide of copper. A piece of bright iron dipped in its solution gets a coating of metallic copper.

Metals.	*Tests.*
IRON. (Ferrous)	With **Ferridcyanide of Potassium,** gives Turnbull's blue. With **Ferrocyanide of Potassium** it gives a precipitate—first of a bluish grey colour, rapidly becoming blue owing to the absorption of oxygen.
IRON. (Ferric)	With **Ferrocyanide of Potassium,** gives Prussian blue. With **Ferridcyanide of Potassium** it gives no precipitate, but turns the liquid to a greenish or olive hue, according to its strength. This fact serves to distinguish ferric or persalts from ferrous or protosalts.
MERCURY. (Mercurous)	With **Iodide of Potassium,** gives the green iodide of mercury. With **Lime Water** it gives a black precipitate of mercurous oxide (*Lotio Nigra*).
MERCURY. (Mercuric)	With **Iodide of Potassium,** gives red iodide of mercury. With **Lime Water** it gives a yellow precipitate

Metals.	*Tests.*
MERCURY. (**Mercuric**) (*continued*)	of mercuric oxide (*Lotio Flava*). Place a piece of bright **Copper** in a solution of any salt of mercury, mercuric or mercurous, and heat in a test tube, the copper becomes coated with mercury. Pour off the fluid, wash the copper gently and dry it, then heat it to redness in a test tube, when the mercury will sublime and condense in globules on the cool part of the tube.
LITHIUM.	Moisten the end of a platinum wire with a solution of a lithium salt, and hold it in the FLAME of a Bunsen burner or spirit lamp—a beautiful crimson tinge is imparted. The other substances tested by flame are sodium and potassium.
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Metals.	*Tests.*
LEAD.	With **Iodide of Potassium,** gives a yellow precipitate of iodide of lead. In order to detect the presence of lead in water, acidulate a pint of it, pass in sulphuretted hydrogen; if it be present, there will be a brownish discoloration produced owing to the formation of sulphide of lead.
POTASSIUM.	With a few drops of **Hydrochloric Acid** and **Perchloride of Platinum,** gives a yellow granular precipitate of double chloride of potassium and platinum. It imparts a violet tinge to flame. Tartaric acid gives with potash the acid tartrate, thus serving to distinguish it from soda.
SODIUM.	Heated on a platinum wire in a non-luminous FLAME, an intensely yellow colour is produced, which is not seen when viewed through blue glass.

Metals.	*Tests.*
ZINC.	With **Ammonium Sulphide,** gives a white precipitate of sulphide of zinc. With liquor ammonia it gives a white precipitate of hydrate of zinc, soluble in excess; this serves to distinguish it from aluminum—the hydrate of the latter being insoluble in slight excess of ammonia.
IODINE:	With **Starch Paste,** gives a blue colour, due to the production, it is said, of iodide of starch. In testing for iodine in the form of an iodide, it is necessary first to liberate it before adding the starch paste. This is done by cautiously adding a little chlorine. In testing bromine for iodine, the bromine must nearly all be converted into hydrobromic acid by a solution of sulphurous acid before the starch paste is added.
BROMINE.	With **Starch Paste,** gives a yellow colour, due perhaps to the production of bromide of starch. In test-

Metals.	*Tests.*
BROMINE. (*continued*)	ing a bromide, it is necessary to liberate the bromine before adding the starch paste. This is done in the same manner as the liberation of iodine, viz., by the addition of chlorine.
CHLORINE.	Destroys the colour of a dilute solution of SULPHATE OF INDIGO.

TESTS FOR THE ACIDS.

Acids.	*Tests.*
SULPHURIC or SULPHATE.	With **Chloride of Barium,** gives a white precipitate of sulphate of barium insoluble in boiling nitric acid.
PHOSPHORIC or PHOSPHATE.	With **Ammonio-Nitrate of Silver,** gives a canary yellow precipitate of ammonio-phosphate of silver. Arsenic gives a similar reaction, but only in perfectly neutral solutions.

Acids.	*Tests.*
OXALIC or OXALATE.	With **Chloride of Calcium,** gives a white precipitate of oxalate of lime, insoluble in acetic acid, soluble in hydrochloric acid. Lime is the antidote to poisoning by oxalic acid, its oxalate being insoluble in the intestinal fluids.
CARBONIC or CARBONATE.	With **Lime Water,** gives a white precipitate of carbonate of lime. Carbonates should first be decomposed by hydrochloric acid.
HYDRO-CHLORIC or CHLORIDE.	With **Nitrate of Silver,** gives a white precipitate of chloride of silver, *soluble* in liquor ammonia. This serves to distinguish it from prussic acid, which also gives a white precipitate with nitrate of silver, the cyanide of silver thus formed being soluble *with difficulty* in liquor ammonia.
HYDRO-CYANIC or CYANIDE.	With a solution of the **Sulphate and Persulphate of Iron, Caustic Potash and Hydrochloric Acid,** gives Prussian blue.

Acids.	*Tests.*
NITRIC. (Strong)	Poured on **Copper** filings gives orange coloured fumes.
DILUTE or NITRATE.	Add a crystal of **Sulphate of Iron,** pour in some **Sulphuric Acid;** where this meets with the iron crystal a black ring is formed.
TARTARIC or TARTRATE.	With a solution of **Acetate of Potash,** gives a white precipitate of acid tartrate of potash. If in the form of a tartrate, previously acidulate with acetic acid.
CITRIC or CITRATE.	Boiled with **Chloride of Calcium,** gives a white precipitate of citrate of lime insoluble in caustic potash; this serves to distinguish it from tartaric acid, which also gives a precipitate with chloride of calcium.
ACETIC or ACETATE.	Heated with strong **Sulphuric Acid,** gives the odour of vinegar.

TESTS FOR THE ALKALOIDS.

Alkaloids.	*Tests.*
ACONITIA.	When rubbed on the skin it causes a tingling sensation, followed by prolonged numbness. To concentrated **Phosphoric Acid** it imparts a lasting violet tint. (Fluckiger.)
ATROPIA.	With **Perchloride of Gold,** gives a citron yellow precipitate; one drop of a dilute aqueous solution powerfully dilates the pupil.
CONIA.	Has a strong odour which has been compared to that of mice. Hemlock leaves or fruit rubbed up with a solution of **Caustic Potash** gives this characteristic smell.
MORPHIA. (Opium)	With a strong solution of the **Perchloride of Iron,** gives a dirty blue colour. Meconic acid with perchloride of iron gives a red colour due to the formation of meconate of iron. Sulphocyanide of

Alkaloids.	*Tests.*
MORPHIA. (Opium) (*continued*)	potassium, found in saliva, also gives a red colour with perchloride of iron; corrosive sublimate destroys this coloration, but does not do so in the case of meconic acid. Opium, containing morphia and meconic acid, is recognised by the above tests.
QUININE.	With **Chlorine Water** and **Solution of Ammonia**, gives an emerald green colour, due to the production of a substance termed thalleioquin.
STRYCHNIA.	Put a few drops of a solution of strychnia on a white plate; near to it place a small fragment of **Bichromate of Potash**; to this add a few drops of **Sulphuric Acid**; when the acid has become fairly tinged, draw it towards the strychnia by means of a glass rod; on contact, a play of colour takes place, commencing with purple, quickly fading into a yellowish red.

Alkaloids.	*Tests.*
STRYCHNIA. (*continued*)	**Physiological Test.**—Place a small frog in an ounce of water to which $\frac{1}{100}$ of a grain of strychnia has been added; in two or three hours, tetanic spasms and death.
BRUCIA.	With **Nitric Acid**, gives an intense red colour. This fact enables us to distinguish nux vomica from cusparia bark.

There are three special tests for **Arsenicum**, viz.: Reinsch's, Marsh's, and Fleitmann's.

Reinsch's Test.

Acidulate with hydrochloric acid a solution containing arsenic; in this place a slip of bright copper; on this arsenicum becomes deposited, an equal amount of copper passing into the solution. Pour off the liquid, wash and dry the copper, then heat it in a test tube: the arsenicum sublimes and is deposited (in the form of octahedral crystals) on the cool part of the tube.

Marsh's Test.

In a wide-mouth bottle, fitted with a cork pierced by a funnel, and a delivery tube bent to a right angle, generate hydrogen gas by means of zinc, and dilute sulphuric acid. When the action has been going on for some time, and the whole of the air expelled from the apparatus, ignite the hydrogen at the end of the delivery tube, and hold a piece of porcelain against the flame; if a dark stain be produced upon it the materials must be rejected as impure. Should the ingredients prove pure, add the arsenical solution through the funnel tube, observe that the flame now burns with a livid bluish colour, owing to the presence of arseniuretted hydrogen, AsH_3. Again hold a piece of porcelain against the flame; on it a brown stain of arsenicum will be deposited. Antimony gives a similar stain, but differing from that due to arsenicum, in the fact that it is not dissolved by a solution of chlorinated lime, whereas the arsenicum stain is dissolved by this solution.

Fleitmann's Test.

Generate hydrogen gas by heating zinc in a test tube with a solution of caustic potash or soda, drop into this tube a little arsenical solution, and spread over the mouth of it a cap of filter paper moistened with one drop of solution of nitrate of silver. Again

heat the tube; arseniuretted hydrogen is now evolved, and this in passing up through the cap reacts on the nitrate of silver, causing a purplish black spot to be produced.

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